Abstract prepared for the NIST ANNUAL CONFERENCE ON FIRE RESEARCH, Gaithersburg Hilton Hotel, Gaitersbusg, MD, October 28-31, 1996

Critical Conditions for Extinction and Transient Pyrolysis Decay in Solid Material Fires

by

Michael A. Delichatsios, FMRC, Norwood MA.02062

BACKGROUND AND INTRODUCTION

A new flame extinction condition [1] for the critical mass pyrolysis rate has been developed when extinction occurs by interaction of flames with the pyrolyzing surface of a condensed material. The extinction conditions provide both the critical mass pyrolysis rate and the corresponding convective heat flux to the surface. The extinction conditions are derived from simple analysis of combustion and heat transfer, and they are shown to be applicable for various experimental conditions such as fuel dilution by inert gas, oxygen dilution by inert gas, effects of external heat flux, material preheating, transient (charring) pyrolysis, including geometric effects which influence the critical mass pyrolysis rate through an effective heat transfer coefficient. Additional validation of the proposed extinction conditions is provided by numerical simulation reported in literature in the regime of low straining rates for a stagnation flow on a cylinder. The present approach can be used to measure critical extinction conditions in a flammability apparatus and allow them to be applied in other conditions such as in microgravity. The critical conditions can be used to apply models for the transient decay of pyrolysis when an extinguishing agent is applied until extinction or a new steady state pyrolysis/burning is reached.

TRANSIENT PYROLYSIS DECAY

We consider the following scenario which has also been reproduced experimentally. A slab of solid material (10 cm x 10 cm x 2.54 cm thick) is burning at steady state conditions in a horizontal or vertical orientation. At a given time, a suppression agent is applied so that the heat flux to the surface is decreased either by direct cooling (by water drops on the surface) or weakening of gaseous reactions (by inerting of gaseous phase). If this cooling is effective within times shorter than the thermal response of the material, pyrolysis rates will drop suddenly before recovery to a new steady state (see Fig.1a where reduction of heat flux is effected by inerting of the oxidant stream and Figure 1b where reduction of heat flux is effected by sudden decrease of the externally applied heat flux. Both experiments were conducted in FMRC flammability apparatus.} Otherwise, if cooling is not applied "fast" or uniformly, sudden drop in pyrolysis does not occur and the decay time is controlled by the solid material thermal response. This is the case for surface water application [2] as shown in Figure 2 for the correlation of times to extinction using the thermal response properties of the material (in all cases in Figure 2 the water application rates are such that extinction occurs).

References

1. Delichatsios, M. A. " Required Water Density for Fire Extinguishment or Control" Final report for NIST Grant # 60NANB4D1675, submitted for publication, 1996.

2. Magee, R. S. and Reitz, R.D. Fifteenth Symposium International on Combustion, The Combustion Institute, Pittsburgh, PA, 1975.

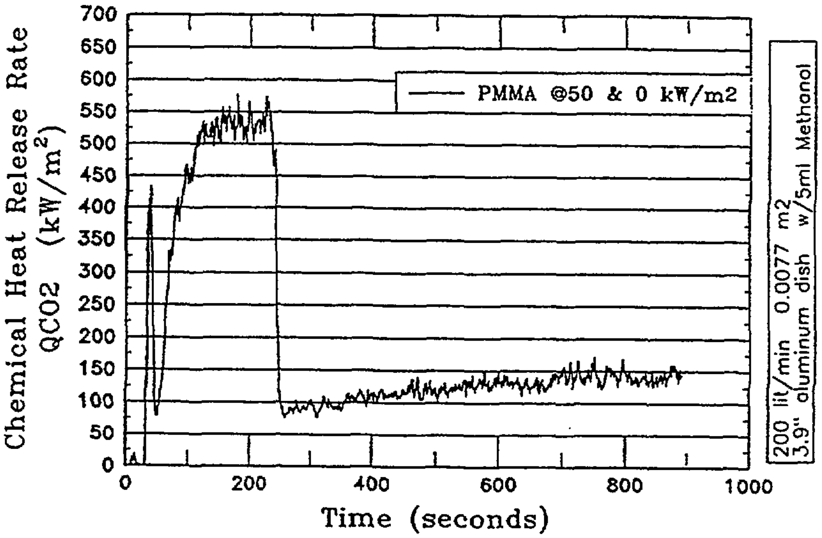

Figure 1. A similar plot as in Figure.1a but the change involves the sudden variation of external heat flux from 50 kW/m² to zero. The final state is supported by the flame heat flux (FMRC flammability apparatus).

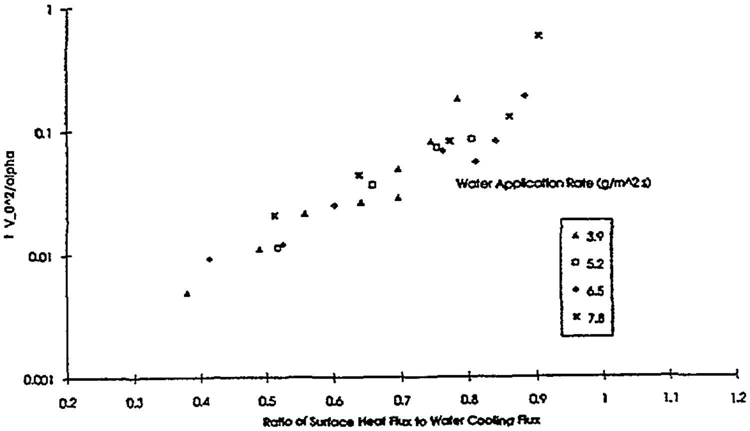

Figure 2. Correlation of time to extinction of PMMA slabs by surface water application [2]. The time is normalized by a thermal response time corresponding to the thermal profile just before water application.